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SYSTEMS OF MEASUREMENT

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Abstract
Wittgenstein and Kripke disagree about the status of the proposition: the Standard Metre is one metre long. Wittgenstein believes it is necessary. Kripke argues that it is contingent. Kripke's argument depends crucially on a certain sort of *thought-experiment* with which we are invited to test our intuitions about what is and isn't necessary. In this paper I argue that, while Kripke's conclusion is strictly correct, nevertheless similar Kripke-style thought experiments indicate that the metric system of measurement is after all relative in something like the way Wittgenstein seems to think. Central to this paper is a thought-experiment I call *The Smedlium Case.*

The standard metre

In his *Philosophical Investigations*, Wittgenstein makes the following intriguing remark.

> There is one thing of which one can say neither that it is a metre long, nor that it is not one metre long, and that is the Standard Metre in Paris. – But this is, of course, not to ascribe any extraordinary property to it, but only to mark its peculiar role in the language-game of measuring with a metre rule.[1]

In *Naming and Necessity*, Kripke takes issue with Wittgenstein. Using '*S*' to refer to 'a certain stick or bar in Paris', Kripke objects as follows.

> This seems a very 'extraordinary property', actually, for any stick to have. I think [Wittgenstein] must be wrong . . . Part of the problem which is bothering Wittgenstein is, of course, that this stick serves as a standard of length and so we can't attribute length to it. Be this as it may (well, it may not be), is the

[1] Wittgenstein, Ludwig, *Philosophical Investigations*, trans. G. E. M. Anscombe (Oxford: Basil Blackwell, 1953), I §50.

> statement 'stick S is one meter long', a necessary truth? Of course its length might vary in time. We could make the definition more precise by stipulating that one meter is to be the length of *S* at time t_0. Is it then a necessary truth that stick *S* is one meter long at time t_0? Someone who thinks that everything one knows *a priori* is necessary might think: 'This is the *definition* of a meter. By definition, stick *S* is one meter long at t_0. That's a necessary truth.' But there seems to me no reason so to conclude, even for a man who uses the stated definition of 'one meter'. For he's using this definition not to *give the meaning* of what he called the 'meter', but to *fix the reference* . . . There is a certain length which he wants to mark out. He marks it out by an accidental property, namely that there is a stick of that length. Someone else might mark out the same reference by another accidental property. But in any case, even though he uses this to fix the reference of his standard of length, a meter, he can still say, if heat had been applied to this stick *S* at t_0, then at t_0 stick *S* would not have been one meter long.

Kripke raises three separate questions in this paragraph. First, does 'one metre' have the *same meaning* as a definite description, eg. the description 'the length of the Standard Metre'?[2] Second, is it *a priori* that the Standard Metre is one metre long? Third, is it *necessary* that the Standard Metre is one metre long? Kripke accepts that it is a priori that the Standard Metre is one metre long (at time t_0). However, Kripke denies that it is necessary. He also denies that 'one metre' is synonymous with 'the length of stick *S* (at time t_0)'.

To which of the three questions does Kripke suppose Wittgenstein would answer 'yes'? he suggestion seems to be: to all three.

[2] Kripke, Saul, *Naming and Necessity* (Oxford: Basil Blackwell, 1980), pp. 54–55. As is now well-known, the modal intuition to which Kripke here appeals – intuitively, the Standard Metre might *not* have been one metre long – fails to support at least one of the conclusions Kripke wishes to draw, i.e. the conclusion that 'one metre' does not have the same meaning as a description. 'One metre', as defined by reference to the length of stick *S*, might yet be synonymous with, say, the description 'the length of stick *S* at t_0 *at the actual world*', where the effect of adding 'at the actual world' is to rigidify the description. I set to one side the issue of whether 'one metre' is a descriptive name (by a descriptive name I mean a name sharing the same meaning as a definite description).

The necessity claim

I am going to focus here on the dispute over whether it is necessary that the Standard Metre is one metre long. I shall assume in this paper that Wittgenstein believes it is necessary.[3]

Why might Wittgenstein believe this? Kripke's suggestion appears to be: because the expression 'one metre' is *defined* by reference to the length of the Standard Metre. Therefore what is expressed by the sentence:

(T) 'The length of the Standard Metre is one metre'

is true by definition and so necessary.

As Kripke points out, the reasoning here is flawed. In fact, even if we accept that 'one metre' is defined by reference to the length of the Standard Metre, there are (at least) two ways in which such a definition might be understood. One might understand 'one metre' to be defined either in such a way that the following holds:

> an object o at any time t and possible world w is one metre long at t at w if and only if o is the same length at t at w as is the Standard Metre at t at w,

or alternatively in such a way that this holds:

> an object o at any time t and possible world w is one metre long at t at w if and only if o is the same length at t at w as the Standard Metre is at t_0 at @ (where t_0 is a particular time and @ is this, the actual world).

Of course, if 'one metre' were defined in the former manner, then it would be necessary that the Standard metre is 'one metre' long.

However, if Kripke is correct, the expression 'one metre' is not so defined. According to Kripke, 'one metre' designates with respect to any arbitrary time and world, not the length of the Standard Metre whatever it might happen to be at that time and world, but rather that length which the Standard Metre happens

[3] Some Wittgensteinians may object that his view is *not* that it is a 'necessary truth' that the length of the Standard Metre is one metre. They may insist that the expression 'necessary truth' is laden with metaphysical baggage that Wittgenstein would certainly reject. Whether or not my use of the expression 'necessary truth' is appropriate in this case, it does at least seem safe to say that, on Wittgenstein's view, what is expressed by 'The Standard Metre is one metre long' is not a *contingent* truth. The dispute between Wittgenstein and Kripke could easily be re-articulated in these terms.

to possess at a particular time at this, the actual world. Hence it is contingent that the Standard Metre is one metre long: it might not have been the length it actually is.

Kripke expresses this point by saying that 'one metre' is a *rigid designator*. It designates the same length – i.e. that length actually, currently possessed by the Standard Metre – with respect to every possible world. If 'one metre' were defined in the former manner, however, then it would not rigidly designate that length.[4]

Why favour Kripke's view of how 'one metre' functions over Wittgenstein's? What settles the matter, it seems, is a certain *thought experiment*. We are invited to test our modal intuitions on an imaginary case, the case in which the Standard Metre (Kripke's 'stick *S*') is heated just prior to t_0, thus making it a little longer. Under these circumstances, is the Standard Metre one metre long at t_0? My intuitions say no. The Standard Metre would be more than one metre long at t_0. But then it is not a necessary truth that *S* is one metre long at t_0.[5]

My aim in this paper is threefold. First, I explain why the reasoning Kripke thinks leads Wittgenstein to suppose that the Standard Metre is necessarily one metre long is unlikely to be Wittgenstein's. Second, I provide a more plausible account of why Wittgenstein might suppose that the Standard Metre is necessarily one metre long. Third, and most importantly, I explain why I believe there is after all something to Wittgenstein's view – the metric system *is* relative in something like the way Wittgenstein seems to think; only it is not relative to the Standard Metre or any of our metric measures, but to what I call a broader *frame of reference*.

[4] 'One metre' is now defined, at least in scientific circles, not by reference to the length of the Standard Metre, but in terms of the wavelength in vacuo of the orange radiation of the krypton-86 atom. The Wittgensteinian may insist that it must, then, be a necessary truth that of the wavelength in vacuo of the orange radiation of the krypton-86 atom is one metre. But of course the same Kripkean intuitions of contingency arise in this case too. Presumably, the wavelength in vacuo of the orange radiation of the krypton-86 atom might not have been one metre (i.e. there are possible worlds – worlds at which the laws of nature are different – at which that wavelength is not one metre).

[5] Note, incidentally, that the contingency to which Kripke appeals here can *not* adequately be explained simply by pointing out that we might not have used the Standard Metre to define 'one metre', or by pointing out that we would no doubt cease to use the Standard Metre to define 'one metre' if it were suddenly to alter in length (I have heard both suggestions made by defenders of Wittgenstein's comment on the Standard Metre). Both suggestions are countered by noting that, even when it is clearly acknowledged that 'one metre' is being used in accordance with its actual, current definition, intuition *still* suggests that the Standard Metre is only contingently one metre long.

I begin by distinguishing two different ways in which objects are used as samples.

Two uses of samples

Consider the following two ways of using an object as a sample:

> *The use of an object as a definitional sample.* What I shall mean by a *definitional sample* is a sample used for the purposes of defining the meaning of a linguistic expression. The use of stick *S* to define 'one metre' in the manner Kripke describes would be one example. Similarly, one might define the word 'pencil' by means of a pencil, or the word 'red' using a swatch of material.
>
> *The use of an object as a standard sample.* Suppose that, while doing some home repairs, I discover that I have lost my tape measure. So I improvise a rule out of a piece of wood dowel. I lay the stick alongside various objects, noting how many multiples of its length or fractions thereof are the lengths of those other objects. I call this using an object as a *standard sample*. Other examples include: using a tuning fork to bring musical instruments into tune with each other; using a colour chart to match tins of coloured paint in a store to the paint on one's walls at home.

Notice that an object functioning as a standard sample needn't function as a definitional sample. I might measure using a piece of wood dowel without ever introducing a name for its length. Conversely, an object used to define needn't function as a standard. In fact, you might define 'red' using as your sample something it would be impossible to use as a standard, e.g. an object that undergoes constant, unpredictable colour changes. You might still point to it at the appropriate moment and say '*That*'s red'.

The Standard Metre is of course used in both these ways.

Now the line of reasoning Kripke attributes to Wittgenstein is as follows. The Standard Metre is used to *define* 'one metre'. So it is true by definition and thus necessary that the Standard Metre is one metre long. Yet it is with the 'peculiar role' of the Standard Metre in 'the language-game of *measuring* with a metre rule'[6] that

[6] Wittgenstein, *Philosophical Investigations*, I §50; my italics.

Wittgenstein is most concerned at *Philosophical Investigations* §50. Kripke presents Wittgenstein as focusing on the use of the Standard Metre as a definitional sample, whereas Wittgenstein is actually most concerned with its use as standard sample, as a measure. It seems unlikely, then, that the reasoning Kripke attributes to Wittgenstein is Wittgenstein's.

The *W*-system of measurement

So how might the Standard Metre's use as measure be relevant to the claim that the Standard Metre is necessarily one metre long? I think the most plausible answer to this question is that Wittgenstein is operating *with a particular conception of what it is for an object to function as a measure.*

Consider the following definition. Let the reference of 'one *W*' with respect to any arbitrary time *t* and possible world *w* be *the length that stick W has at t at w* (and be empty otherwise). Thus stick *W* can never be and could never have been anything other than one *W* long. It is a necessary truth that, if it exists, *W* is one *W* long.

Having thus defined 'one *W*', we can now set about expressing the length of a given object as a multiple/fraction of one *W*. Let's say that an object at a given possible world *w* and time *t* is 0.5 *W* long if and only if it is exactly half the length of *W* at *w* at *t*, that it is 2 *W* long if and only if it is twice as long as *W* at *w* at *t*, and so on.

Notice that in this system of measurement stick *W*'s length in *W*s at any arbitrary time and/or world is stipulatively held constant. Stick *W* is necessarily one *W* long. Shrink or stretch it: stick *W* remains one *W* long. Indeed, by shortening stick *W* one alters the *W* dimensions of *other* objects.

I shall call this *the W system of measurement.*[7] As we saw above, it's the 'peculiar role' of the Standard Metre as a *measure* that leads Wittgenstein to suppose that the Standard Metre is necessarily one metre long. It seems plausible, then, that on Wittgenstein's view *the 'peculiar role' assigned to the Standard Metre in the metric system is precisely that which is assigned to stick W in the W system.* That would neatly explain the necessity claim.

[7] I acknowledge, of course, that this is a 'system of measurement' only in a restricted sense. Objects now have *W* measurements. But of course there is no actual practice here of *using stick W to measure things*.

Many measures

There is, however, an obvious difference between the metric system and the *W*-system: in the metric system *more than one measure* is used. We all have our own metric measures.

But the metric system could still be relative in something like the way the *W* system is relative. The metric system might be what one might call a *majoritarian* system. Consider a practice in which many different sticks are used to measure the length one *M*. It's stipulated that to be one *M* long is to be the same length as the *majority* of these sticks. More precisely: for an object *o* to be one *M* long at any world *w* and time *t* is just for *o* to possess whatever length is possessed by the majority of the relevant sticks at *w* at *t*. Hence if one stick had its length reduced by ten percent but the rest remain unchanged, then that particular stick would now be only 0.9 *M* long. So it's contingent that *any particular* stick is one *M* long. Call this *the M-system of measurement.*

The *M*-system is obviously similar to the *W* system. *Something* is assigned a role analogous to that assigned to stick *W* in the *W* system. The difference is that in the *M*-system it is not one particular measure but the majority of measures that is assigned that role. I shall call all systems of measurement involving one or more measures where what is assigned the role of stick *W* is either a single measure or else a subset or percentage of those measures *W-type systems of measurement.*

Is the metric system like the *M*-system? Obviously, that cannot be Wittgenstein's view. If to be one metre long is to be the same length as the majority of our metre rules, then, *pace* Wittgenstein, it would be a contingent fact that the Standard Metre is one metre long. Wittgenstein, I suggest, believes both that all systems of measurement are essentially *W*-type, and also that in the metric system it's the Standard Metre *alone* that plays the role of stick *W*. That's its 'peculiar role'.

However, our modal intuitions suggest that the metric system is not any sort of W-type system – not even a majoritarian system. If the metric system were a *W*-type system, then it should be impossible for *all* our metric measures simultaneously to have their metric dimensions reduced by 10%. But, intuitively, this could happen. If, for example, there was a complex plot by Martians to shave down all our metre rules during the night, then all our metre rules might end up 0.9 metres long.

The K-system of measurement

How, then does the metric system function? In fact it seems to be what I call a *K-type system of measurement*. Suppose we introduce the expression 'one *K*' to refer to that length which stick *K* happens actually to possess at t_0. We might then go on to measure length in *K*s using stick *K*, and do so quite accurately, just so long as stick *K* remains the same length. But then, even though the length of *K* is used to measure length in *K*s – indeed, even though it be the *only* thing we use to measure length in *K*s – it is nevertheless contingent that stick *K* is one *K* long. For stick *K* might not have been the length it actually is. Let's call any system of measurement in which all measures are used in this way *K-type*.

An implication of Kripke's views about how the expression 'one metre' functions is that the Standard Metre has the same sort of role in the metric system in the same sort of way as stick *K* has in the *K* system. On Kripke's view, 'one metre' names a certain length: that length which the Standard Metre happens currently to possess. Thus the Standard Metre is only correctly used to measure length in metres on the condition that it remains that same length. Intuitively, it seems Kripke is right about this.

In fact, it seems that, while we certainly might introduce a *W*-type system of measurement, all our actual systems of measurement are K-type and not W-type. For example, consider a situation in which all our kilogram weights have their weight reduced by 10% overnight, everything else remaining the same. When I test my modal intuitions with the question, "What would be the weight in kilograms of those kilogram weights?" they say they would weigh only 0.9 kilograms. It would surely be wrong to describe the weight in kilograms of everything else as having increased. So the metric system of measuring weight would also appear to be a *K*-type system.

The background to *K*-type systems of measurement

Wittgenstein apparently believes that all systems of measurement are *W*-type. But our modal intuitions suggest our actual systems are *K*-type.

But perhaps Wittgenstein is not wholly wrong. As I will argue shortly, it does seem that *something* functions in the metric system in a manner analogous to the way stick *W* functions in the *W* system, even if it isn't any of our measures.

Let's now turn to *The Smedlium Case*.

The Smedlium Case

Imagine a world quite similar to our own that contains large quantities of a metal-like material – let's call it *smedlium* – which gradually and unpredictably alters in size. All smedlium objects expand and contract in unison. At one o'clock on one particular day all the smedlium objects are 5% larger than they were at midday; at two o'clock they are all 10% smaller, and so on. Despite this peculiarity, smedlium remains a useful material. In fact, it is the strongest and most durable material available. One of the inhabitants of this world builds machinery made wholly out of smedlium. The machines are used in situations where their size relative to non-smedlium objects doesn't matter. The smedlium engineer constructs and calibrates a measuring rule made out of smedlium to use when manufacturing such machines. She measures dimensions in '*S*'s, one *S* being measured against the length of her smedlium measure. Of course, so far as manufacturing smedlium machines is concerned, a smedlium measure is far more useful than is a rule made out of some more stable material, for it allows the smedlium engineer to ignore the changes in size of the object upon which she is working. For example, she knows that, say, if the hole for the grunge lever measured 0.5 *S* in diameter at one o'clock, then a grunge lever which measures 0.5 *S* in diameter at two o'clock will just fit into that hole, despite the fact that the hole is now noticeably smaller than it was at one o'clock.

Now one might think that *here at least is one case in which a measuring rod functions as does stick W in the W system, not as does stick K in the K system.* Surely, one might argue, what 'one *S*' designates with respect to any arbitrary time and world is the length of the smedlium engineer's measuring rod whatever it might be at that time and world, not the length that it actually possesses at some particular moment in time. The smedlium system *must* be a W-type system.

And yet, oddly enough, *we have the same modal intuitions about the smedlium system as we do about the metric system.* It seems that the smedlium measuring rod might cease to possess the measurement one *S*. It might actually come to possess e.g. the measurement 0.9 *S*.

Suppose, for example, that mid-way through a month when the smedlium engineer is working on a particularly important project, a saboteur breaks into the smedlium engineer's workshop and indulges in some industrial espionage. The saboteur shaves 10% off the end off the smedlium measuring rod knowing this will cause the smedlium engineer all sorts of problems. Isn't it the case that the smedlium measuring rod no longer possess the measurement one *S*? To me, this certainly seems the right way to describe the situation. Indeed, it seems right to say that the smedlium measuring rod now has the measurement 0.9 *S*, given that it is now 10% shorter than it would otherwise have been.

It also seems right to say that the smedlium measure might never have had the measurement one *S*: it might always have been only 0.9 *S* long (one might tell a story on which the mould in which stick S was originally cast leaks at one end, producing a sightly shorter stick). So, intuitively, it is *contingent* that the smedlium measuring rod possesses the measurement one *S*.

A puzzle for Kripke

So we have the same sort of modal intuitions about the smedlium system as we do about the metric system. However, while it appears to be contingent that the smedlium measuring rod possesses the measurement one *S*, note that there is *prima facie, a problem in applying the Kripkean explanation of the contingency*. We saw that the Kripkean explanation of why it is contingent that the Standard Metre possesses the dimension one metre is that 'one metre' is a *rigid designator*: it rigidly designates a certain *length* – a length the Standard Metre happens only contingently to possess. But note that *this explanation is unavailable when it comes to explaining why it is contingent that the smedlium measuring rod possesses the dimension one S*. Clearly, "one S" doesn't rigidly designate a length. An object can retain the dimension one *S* even while altering in length.

This raises a difficulty for Kripke: it seems that, in the smedlium case, *the intuition of contingency is going to have to be accounted for in some other way*. But if in the smedlium case the contingency is to be explained *other* than by supposing that 'one S' is a rigid designator (of a certain length), then presumably *that same alternative explanation might be provided in the metric case too*.

In fact, one might begin to wonder whether the metric and smedlium systems aren't both *W*-type systems after all. Just how reliable *are* these Kripkean intuitions of contingency upon which so much importance has been placed? Kripke's argument against the metric system being a *W*-type system no longer looks quite so decisive.

Relativizing to a frame of reference

What, then, does explain the intuition of contingency concerning the *S* measurements of the smedlium measuring rod? What does 'one *S*' name, if not a length? Why, if all previous changes in *S*'s length didn't affect its *S* measurements, does the change in its length affected by the saboteur affect its *S* measurements?

In fact the Kripkean explanation *can* still be applied here if we are prepared to introduce a relativized notion of 'length'. As I explain below, one might suggest that 'one *S*' does rigidly designate a 'length' of sorts, it's just that it designates a length relative to a frame of reference other than one with which we are ordinarily familiar.

Arguably, at least some of our judgements concerning sameness of length are made relative to the frame of reference constituted by the medium sized dry goods (trees, hills, houses, rocks and pebbles, etc.) with which are ordinarily surrounded. They constitute the frame of reference relative to which one might correctly describe one's trousers as having shrunk or one's geraniums as having grown taller. Whether or not we already possess such a relativized notion of length, let's now introduce one. Let's say that, on this relativized notion of 'length', two objects at different times and/or worlds differ in 'length' just to the extent that their dimensions expressed as a fraction of the mean of all the dimensions of those medium-sized dry goods at those times and worlds differ. Thus, on this relativized notion of 'length', if, in some actual or counterfactual situation, not only my trousers shrink but so too do all the relevant medium-sized dry goods by the exact same amount, then my trousers continue to remain the same 'length'.

Clearly, 'one *S*' doesn't name a 'length' relative to this frame of reference. However, it may yet name a 'length' relative to some other frame of reference. Suppose, for example, that the frame of reference to which the 'length' in question is relative is constituted by the mean of the dimensions of all the other smedlium objects, including those upon which the smedlium engineer has been working. We might then explain why the change in the length of the smedlium measuring rod affected by the saboteur is a change which, unlike all previous changes in its length, results in it ceasing to possess the measurement one *S*. It's a change which alters its length not just relative to our familiar frame of reference, but also relative to this alternative frame of reference.

A Kripkean resolution of the Smedlium Case

Let's introduce the expressions 'length$_S$' and 'length$_M$' to indicate when we are using the two relativized notions of length outlined above. Differences in length$_M$ are relative to the frame of reference constituted by the sort of medium-sized dry goods actually found in our local environment; differences in length$_S$ are relative to the frame of reference constituted by the smedlium objects.

Having allowed talk about 'length' to be relativized to different frames of reference, we can now provide a Kripkean explanation of the contingency of the smedlium measuring rod being one *S* long can now be applied. 'One *S*' is indeed a rigid designator. It rigidly designates a certain length$_S$. This length$_S$ is only contingently possessed by stick *S*. Stick *S* ceases to possess the length$_S$ one *S* when the saboteur shaves down one end.

But notice that we can only apply the Kripkean explanation if we are prepared to allow for such relativized notions of 'length'. So, *unless Kripke is prepared to allow for such relativized notions of 'length', the smedlium case remains a problem for him.*

A parallel between the smedlium and W-systems

Notice that in the smedlium engineer's system of measurement the designation of 'one *S*' with respect to any arbitrary time *t* and world *w* is tied to the dimensions of the relevant smedlium objects at *t* at *w*. So, although the smedlium engineer's system of measurement is a *K*-type system, nevertheless *something* functions in her system in a manner akin to the way stick *W* functions in the *W* system. Just as, in the *W* system, the *W* dimensions of stick *W* are held constant for all times and worlds, so (we're supposing) in the *S* system the mean of the dimensions of the relevant smedlium objects (or something similar[8]) is held constant for all times and worlds.

Is the metric system like the smedlium engineer's system?

We are now in a position to appreciate that while the intuitions to which Kripke appeals – namely that 'one metre' is a rigid designator and that the Standard Metre is only contingently one metre long – may indeed indicate that the metric system is a *K*-type system, not a *W*-type system, nevertheless these intuitions do *not* indicate that the metric system isn't relative in the same sort of way as the smedlium engineer's system. For *we have analogous intuitions when it comes to the smedlium engineer's system of measurement.*

Indeed, notice that our intuitions about the metric case do not indicate that Wittgenstein isn't right to suppose that *something* functions in the metric system as does stick *W* in the *W* system, though of course they do indicate that Wittgenstein is wrong to suppose that what plays that role is the Standard Metre. That is, it may yet turn out that something plays a role in the metric system analogous to that played by the smedlium objects in the smedlium system.

I will shortly turn to the question of whether the metric system *actually is* relative in this way. But before I do so, let's briefly consider some other similarly relativistic systems of measurement and then contrast them with what I call *absolute* systems of measurement.

Other frames of reference

Notice that, when introducing a system of measurement by defining 'one *K*' by reference to a bar known to be made out of some more familiar and stable material, there are still many different background frames of reference we might adopt. To illustrate, consider the following scenario.

Suppose that a community of astrophysicists (who work only at night) decide to adopt a certain stick – stick *K* – as a measure.

[8] This is probably an oversimplification. See final section.

They carefully store stick *K* in a large box from which they occasionally remove it to check and calibrate their instruments. Coincidentally, the morning after the astrophysicists adopt stick *K* as their measure the park keepers enter the laboratory looking for something to mark out the grounds surrounding the laboratory. They chance upon the stick *K* lying in its box and decide to use it as a rule to measure out and keep a record of the dimensions of the layout of their grounds. Each evening they carefully return stick *K* to its box. And so two practices of using the length of stick *K* as a measure happen to develop quite independently of each other.

Let's also suppose that, again coincidentally, both the astrophysicists and the park keepers use the expression 'one *K*' to name that unit of measurement of which they use *K* as their only measure. Indeed, let's suppose that both communities introduce the expression 'one *K*' to function as a rigid designator of, as they put it, a certain "length": the "length" of stick *K* at time t_0.

Now suppose that, for some strange reason, the planet on which the astrophysicists and park keepers live and everything on it gradually shrinks over a period of one month. Suppose that, relative to a much larger frame of reference, the dimensions of stick *K* at time t_1 are exactly 10% less than they were at time t_0.

Consider the question: does stick *K* retain the measurement one *K* at t_1? The answer to this question depends at least in part upon on what, if anything, constitutes the relevant background frame of reference in each system of measurement. It seems to me that, given the interests and concerns of the park keepers, their system of measurement is likely to be relative to some comparatively local frame of reference. Let's say that the frame of reference in question is constituted by the immediate countryside. In which case the park keepers may truly declare that *K* still retains the dimension 'one *K*' at t_1. If informed about the shrinkage of their planet, the park keepers will dismiss it as an irrelevance: they will insist the *K*-measurements of both stick *K* and their flowerbeds remain unaffected. Given the astrophysicists' interests and concerns, on the other hand (i.e. given that they use their system to frame scientific hypotheses about how the universe as a whole behaves), they may relativize their system of measurement to some much larger frame of reference. Let's suppose that this is the case. Then the astrophysicists may truly declare that stick *K* is only '0.9 *K*' long at t_1.

In short, while both communities define the expression 'one *K*' in such a way that it functions as a rigid designator of that unit of measurement of which they use stick *K* as their sole sample, if their respective systems of measurement are relative to different frames of reference, then they nevertheless use 'one *K*' to refer to different units of measurement. The astrophysicists introduce 'one *K*' as a rigid designator of a length_{A}; the park keepers introduce 'one *K*' as a rigid designator of a length_{P}.

Absolute length

We have looked at a number of different *K*-type systems of measurement of length. Each is relativized to a different frame of reference. But must *all K*-type systems of measurement similarly be relativized?

Maybe not. Perhaps we can correctly describe objects at different times and/or worlds as being *absolutely* the same length – as I shall put it, the same *Length* (with a capital 'L') – as opposed to merely being the same length_{S}, the same length_{M}, the same length_{P}, the same length_{A}, etc. While an attribution of length_{S}, length_{M}, length_{P} or length_{A} etc. to an object in some actual or counterfactual circumstance is always made relative to a frame of reference, an attribution of Length is made independently of any frame of reference.

Krelative and Kabsolute systems of measurement

We are now in a position to distinguish two varieties of *K*-type system: those that are relativized to some frame of reference or other and those that are not. Let's distinguish them by calling the former *Krelative* systems and the latter *Kabsolute* systems.

*K*relative and *W*-type systems of measurement are similar in that both involve something being assigned a role analogous to that assigned to stick *W* in the *W* system. *K*relative systems differ from *W*-type systems in that, although something is assigned a role analogous to that assigned to stick *W*, *it isn't what we use to do our measuring*. Rather, it is what I have been calling the background *frame of reference* that is assigned that role.

Clearly, the smedlium engineer's system is not a *K*absolute system. It is a *K*relative system. I have suggested that in the smedlium system it is the various other smedlium objects that constitute the relevant background frame of reference.

Central conclusion

My primary concern in this paper has been to develop a clearer picture of how the metric system of measurement, and indeed all our systems of measurement, *may* operate. I have, in effect, provided two very different accounts. The metric system may be a *K*absolute system. Or it may be a *K*relative system.

Intuitively, Kripke is right: the metric dimensions of the Standard Metre, and indeed the rest of our metric measures, might all have been, say, ten percent less than they actually are. Our intuitions support the contention that the metric system is a *K*-type system, not a *W*-type system. My central conclusion is that *this intuition is equally consistent with both the hypothesis that the metric system is a Kabsolute system and the hypothesis that the metric system is, like the smedlium engineer's system, a Krelative system.*

*K*relative systems are certainly a possibility, as the smedlium case illustrates. Indeed, as I have explained, we need to acknowledge their possibility in order to apply the Kripkean explanation to our intuitions concerning the smedlium case.

If the metric system is indeed a *K*relative system, then Wittgenstein is partially vindicated. *Something* functions in the metric system as stick *W* functions in the *W* system. It's just that what has this function isn't the Standard Metre, or indeed any of our metric measures.

Final question: Is the metric system a K-relative system?

This brings us to our final question. Granted that the modal intuitions to which Kripke appeals are neutral between the metric system being a *K*relative system and a *K*absolute system, which is it?

I believe the metric system is a *K*relative system. I shall not attempt to make a knock-down case for the conclusion here. But I shall indicate why that seems to me to be the more likely alternative.

Let's begin by anticipating some objections to the suggestion that the metric system is a *K*relative system.

You might argue that the metric system must be a *K*absolute system for the following reason. A definition of the expression 'one metre' by reference to the length of the Standard Metre will typically take place in the absence of any deliberation concerning what, if anything, is to constitute the relevant frame of reference. Indeed, don't we thereby succeed in 'fixing the reference' of 'one metre' with respect to any arbitrary time and world without our having to adopt any frame of reference at all? If so, then 'one metre', thus defined, must designate an absolute Length rather than a length relativized to some frame of reference or other. But then the metric system must be a *K*absolute system, not a *K*relative system.

This objection is easily dealt with. Compare the smedlium engineer's system of measurement. She introduces 'one *S*' to name that unit of measurement of which she uses stick *S* as her only measure. Now her definition of 'one *S*' is certainly also unlikely to involve any *explicit* appeal to a frame of reference. Indeed, that her system of measurement is relativized to frame of reference, let alone that it is relativized to a frame of reference constituted by the other smedlium objects, may well be a fact of which she is not fully cognizant. Yet it is clear that her system of measurement nevertheless *is* relative to a frame of reference. Obviously, 'one *S*' does not name a Length. It names a length_S (or something similar). So the engineer's 'reference-fixing' definition of 'one *S*' by reference to stick *S* must involve at least an *implicit* appeal to some frame of reference or other. Presumably, what functions as the relevant frame of reference in the smedlium case is determined, not by any conscious decision on her part, but by (broadly speaking) the *use* to which she puts her system of measurement.[9]

But then the fact that we may similarly define 'one metre' without giving any thought to what, if anything, is to constitute the relevant frame of reference is similarly consistent with the metric system also being a *K*relative system.

I acknowledge that a difficult question remains, however: if our talk about 'length' is relative, then *to what* is it relative? – I touch on this question below.

Clearly the suggestion that the metric system – and, indeed, our talk about 'length' generally – is relative to say, the frame of

[9] The suggestion that use may determine what functions as the relevant frame of reference in *K*relative systems obviously deserves more attention than I can give it here. This is but a sketch of a possible reply to the above-mentioned worry.

reference constituted by planet Earth is undermined by the intuition the metric dimensions of the Earth might not have been what they actually are, e.g. they might have been ten percent less. Similar intuitions appear to undermine most of the other more obvious suggestions that might be made concerning what constitutes the relevant frame of reference.

Consider, for example, the suggestion that the frame of reference relative to which our talk of length is relative is constituted by *all* physical dimensions – those of everything in the entire universe. Even this suggestion would appear to be undermined by yet another Kripkean modal intuition: might not *all* these dimensions have been a little less, or become a little less, than they actually, currently are? It seems they might. Indeed, that such a shrinkage had taken place might even be verifiable. If the laws of nature remain unaltered, all sorts of differences will manifest themselves: many processes will take less time to occur; our bodies will suddenly seem stronger, and so on. It may well be that the smoothest and most plausible way to account for all these changes might indeed just be to suppose that everything has shrunk a bit. But if it makes sense to suppose that *everything* might shrink a bit, does that not entail that by 'length' we must mean Length?

Again, not necessarily. The frame of reference need not – or need not just – include the *physical* dimensions of things (by which I mean, roughly, the dimensions of physical objects and the distances between them). It may incorporate, at least indirectly, the laws of nature themselves (for example, if the frame of reference to which a *K*-relative system of measurement is relative is, say, the distance traveled by light in a fixed period of time, then a change in the laws governing light's speed will affect that frame of reference, and thus also the *K*-measurements of things.) So perhaps the frame of reference is constituted by the universe as a whole, *including its laws.* And in fact it is not so clear that we can make sense of the possibility of a universe just like this one except that, while all physical dimensions are reduced slightly, there is also, nevertheless, a corresponding adjustment to the laws of nature effectively cancelling out any possible manifestation of that reduction. Yet if by 'length' we mean Length, we *should* be able to make sense of that possibility. So *our modal intuitions seem finally to favour the view that the metric system is a Krelative system.*

There is a further reason why our difficulty in specifying precisely to what the metric system is relative should not be considered decisive against the suggestion that the metric system is

*K*relative. For note that *we run into similar difficulties when it comes to specifying what constitutes the relevant frame of reference in the smedlium case, a case in which we clearly aren't dealing with a Kabsolute system.*

Consider, for example, my tentative suggestion that the smedlium system is relative to the mean of the dimensions of the relevant smedlium objects. On closer inspection, this suggestion seems not to be quite right. For can't we not envisage counterfactual circumstances in which the mean of the dimensions of the relevant smedlium objects, expressed as a fraction/multiple of one *S*, is other than what it actually is? Suppose, for example, that our smedlium engineer invents a machine that shrinks objects (be they made out of smedlium or some other material). Place an object or number of objects (made out of some ordinary material – not smedlium) inside the machine and press the start button and the dimensions of those objects are reduced by 10%. Now suppose that a very large version of this machine is built and *all the smedlium objects that exist* are placed inside and the button pressed. What are the *S* dimensions of all those smedlium objects now? My intuitions favour the suggestion that the *S* dimensions of all those objects have just been reduced by 10%. But then my original suggestion concerning what constitutes the relevant frame of reference in the smedlium case cannot be exactly right. It seems that, though the smedlium system is a *K*relative system, not a *K*absolute system, we run into exactly the same sort of difficulties in specifying to what the system is relative as we do in the metric case. But then the latter difficulties do not count heavily against the suggestion that the metric system is itself a *K*relative system.

There's a another reason for favouring the view that the metric system is *K*relative. Even if we allow that there are such things as absolute Lengths (and perhaps we should not), surely any absolute Length would be too disengaged from actual our practice of measuring, recording, talking about, etc. metric dimensions for it plausibly to be considered a candidate for the reference of 'one metre'.

Final conclusion

It seems to me that the metric system is much more likely to be a *K*relative system than a *K*absolute system. In order to apply the

Kripkean explanation of why it is contingent that the smedlium engineer's measuring rod is one *S* long we need to introduce relativized notions of length. 'One *S*', it seems, *is* a rigid designator: it rigidly designates a length$_S$. This raises the possibility that what 'one metre' rigidly designates is also a length relative to some background frame of reference or other. We have yet to see a cogent objection to the view that the metric system isn't relative in this way.

Indeed, it seems probable that the metric system is a *K*relative system. In which case Wittgenstein is partially vindicated: the metric system *is* relative in something like the way Wittgenstein suggests. Only it is not relative to the Standard Metre, or indeed to any of our metric measures. Rather, it is relative to what I call a background *frame of reference*.

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